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The Geology and Ore Deposits of the Ruby Gulch Mine

Henry J. Roletto

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THE GEOLOGY AND ORE DEPOSITS OF THE RUBY GULCH MINE

by
Henry J. Roletto
and
John X. Combo

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BUTTE**

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

Montana School of Mines
Butte, Montana
May 20, 1947

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THE GEOLOGY AND ORE DEPOSITS OF THE RUBY GULCH MINE

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INTRODUCTION

The Ruby Gulch Mine, owned and operated by the Ruby Gulch Mining Company, Zortman, Montana, is one of the most important low-grade gold producers in the state. Situated in the Little Rocky Mountains, the mine has had an interesting history since its discovery shortly before the turn of the century. Mining has been carried on intermittently since that time. The free-milling gold occurs finely disseminated along minute fractures in a horizon of Precambrian schist and intruded porphyry. Minor amounts of silver are also recovered, and assay returns occasionally report a trace of copper. At the present time the glory hole method of mining is used to extract the ore, and a 26-man crew is employed by the company. A 300-ton cyanide mill is located on the property and the gold recovered is shipped to the U. S. Mint in Denver, Colorado.

This report is offered as a thesis in geology to meet one of the requirements for graduation from the Montana School of Mines. The authors collaborated on all phases

of the work assuming equal responsibility for all specific items covered. This problem was undertaken jointly because of the great distance (437 miles by automobile) of the mine from Butte, and the magnitude of the problem.

Fortunately, maps of both the underground workings and the surface features were available in the files of the Ruby Gulch Mining Company. However, no geologic maps of the property were available. Consequently, these maps were traced by the writers and the geology placed thereon by means of a pacing survey. A Brunton Compass was used to measure strikes, dips, and auxiliary directions. To accomplish this work, the mine was visited several times during the fall of 1946, when the underground and the surface geology was studied, and samples and specimens to be examined in the laboratory were collected. Both polished surface and thin sections studies of the samples obtained were made.

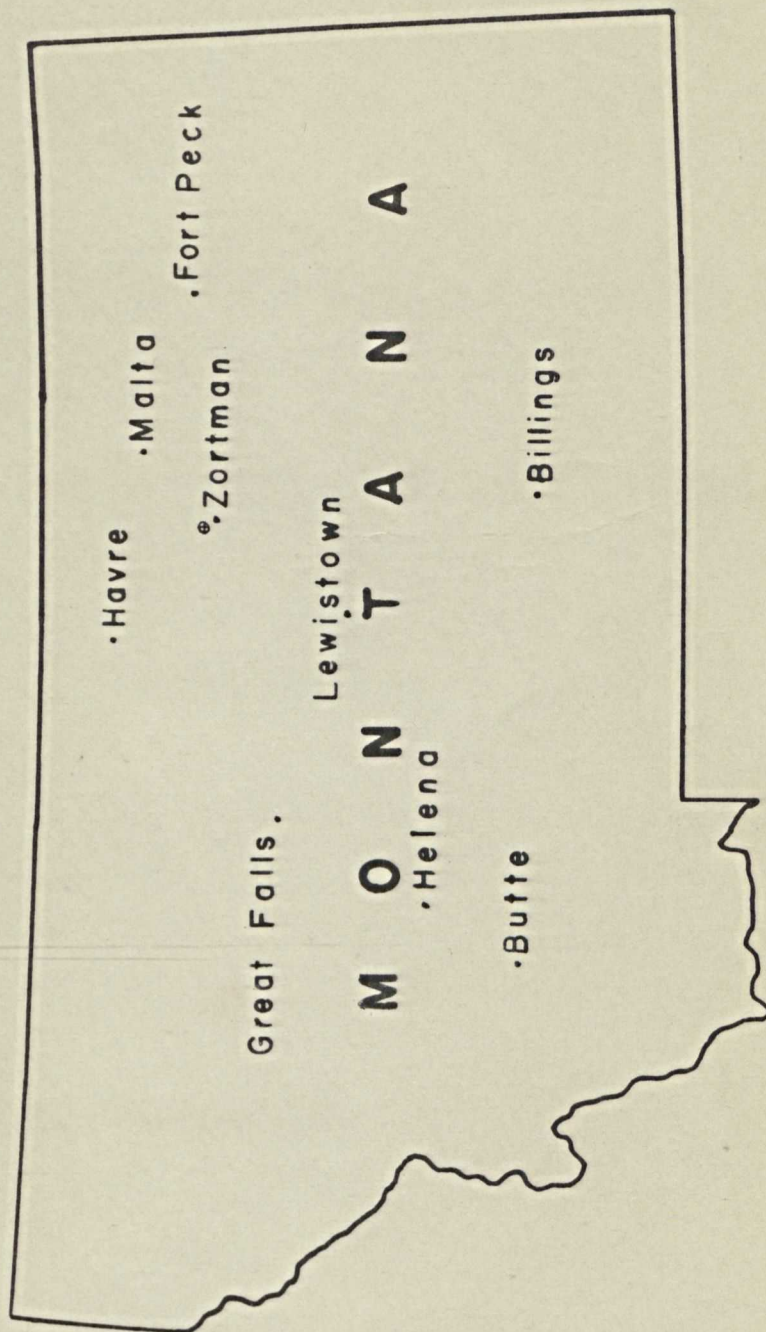
The authors wish to express their appreciation to the directors of the Ruby Gulch Mining Company for their permission to study the mine as a thesis problem; to Mr. Edgar A. Scholz, general manager, for his information, suggestions, and help concerning the geology of the ore deposit; to Dr. Eugene S. Perry, Professor of Geology at Montana School of Mines, for his advice and

guidance in the preparation of this report; to Dr. E. William Heinrich, Assistant Professor of Geology at the same school, for his assistance in the laboratory examination, both macroscopic and microscopic, of the rock and ore samples. The writers are indebted to Mrs. Edgar A. Scholz for her hospitality without which the undertaking would indeed have been much more difficult.

LOCATION AND ACCESSIBILITY

The Ruby Gulch Mine is near the southeastern margin of the Little Rocky Mountains in north central Montana. It lies wholly within section 7 of Township 25 North, Range 25 East, and is approximately one and one-half miles northwest of Zortman (population 275)* in Phillip's County. The county seat, Malta (population 2,215)*, in the Milk River valley, is fifty-two miles to the northeast.

Montana Highway No. 19 extends from Malta to Zortman. The northern twenty-five miles of the road have been oiled, and plans have been made for the completion of the remaining unsurfaced, but graded section. Another improved country road leading from Dodson (population 397)* intersects the Malta-Zortman highway. The road connecting Zortman with Lewistown is unsurfaced and infrequently travelled, since an undependable ferry is the only means of



INDEX MAP

crossing the Missouri river. A narrow mountain road extends from Zortman to the Ruby Gulch Mine. Similarly, other mines in the district are connected by fair mountain roads. Because of the characteristics of the Bearpaw shale, all of these unsurfaced roads are very slippery when wet and may even develop soft gumbo upon excessive rainfall.

The Great Northern Railway, following the Milk River valley, and the Northland Greyhound Lines, using U. S. Highway No. 2, with stations at Dodson and Malta are the only means of public transportation in the district. Zortman has daily mail service through its own post office, Sunday excepted. A telephone system links the mine with the Fort Belknap Indian Agency. However, no other outside calls can be made.

HISTORY

The placer deposits occurring in the beds of the streams that flow southward from the Little Rocky Mountains to the Missouri river have been worked intermittently since the gold rush in 1884, but in general mining was accompanied with but small success until the lode deposits were discovered. These deposits came into prominence in 1893, when gold was found in the August Mine, about five miles southwest of Zortman. As most of the

ore was not of shipping grade, the development of the mines was slow. Production was almost nil until the spring of 1903, when a cyanide mill was completed at Zortman.

The first Ruby Gulch mill was completed in January, 1905 and ore treatment began at the rate of 100 tons per day. In 1907 the capacity of the mill was increased to 300 tons per day.

The following year under the ownership of Phillips and Whitcomb a new electric power plant and crusher were installed, and it became possible to treat 500 tons of ore a day. Underground development work was completed making it possible to supply the mill with ore during the winter months when bad weather made it impossible to work the open cut.

In 1923 the mill was destroyed by fire, and another was not erected until the summer of 1936. During this interval high-grade ore was shipped to the East Helena Smelter, and a dump of low-grade ore was formed to be treated in a proposed mill. Operation of the property ceased on August 9, 1942 due to war-time restrictions.

Operations were resumed on July 1, 1946. At the present time, production is approximately 300 tons of ore per day.

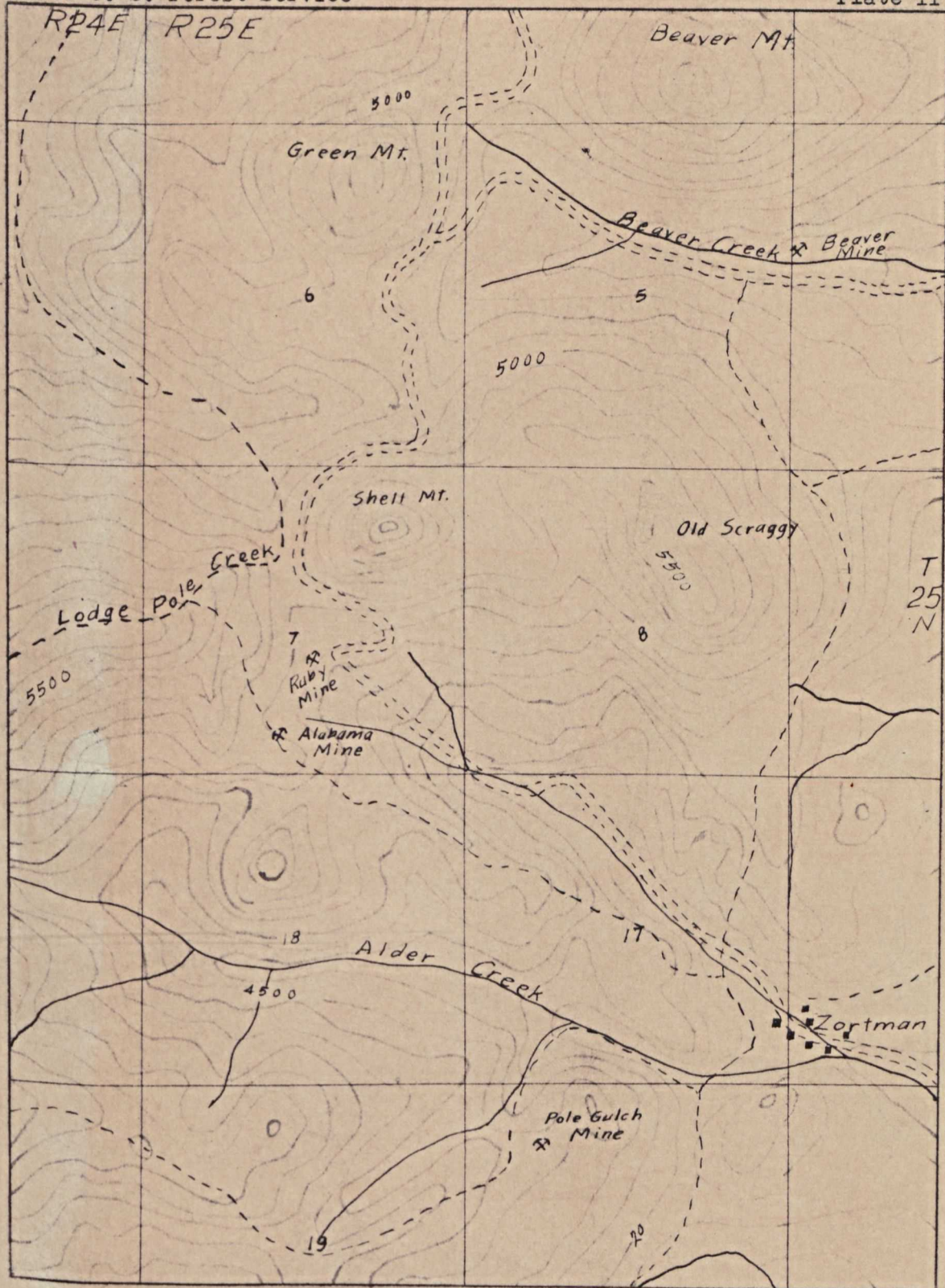
PHYSIOGRAPHY

The Ruby Gulch area is entirely mountainous, characterized by moderately steep mountain slopes. The Little Rockies have an approximate relief of over 2,000 feet. The altitude of the 500 portal of the mine is 4,741 feet above sea level.

The placer streams flowing from the southernmost half of the Little Rockies empty into the Missouri river, while those rising in the northernmost portion drain into the Milk River. Alder Creek provides ample water, even during the late summer and winter months, for all present mining, milling, and domestic needs, although freezing conditions often make maintenance of the supply difficult.

The climate is typical of that of other mountain areas in Montana. The temperature range is -40° F to 95° F and averages approximately 41° F. The average annual precipitation is approximately 14 inches.

The low winter temperatures are accompanied by a dry atmosphere. The summer weather is not oppressively hot during the day and nights are chilly. Mining and milling operations may be carried on throughout the year. However, excessive cold weather hampers surface operations in the open pits and, as a result, production declines.



**TOPOGRAPHIC MAP OF THE
RUBY GULCH AREA**

Vegetation is rather abundant. The surface mapped is covered with scrub pine and various kinds of bunch grasses. Cottonwood and willow trees are present along the streams and ditches. The surrounding areas provide trees of sufficient size for use as mine timbers. Western Yellow Pine is the most prevalent with Larch, Douglas Fir, and Lodgepole Pine occurring in much lesser abundance.

REGIONAL GEOLOGY

General Character

The Little Rocky Mountains were formed as a result of a laccolithic intrusion accompanied by uplift and peripheral faulting. The result effected is a dissected domal structure. The center of the mass is porphyry of a character peculiar to laccoliths, except where erosion has exposed the underlying schists and gneisses, or where eroded sediments, which girdle the dome, remain as more or less concentric bands surrounding the inner core.

Stratigraphy

The schist and gneiss of this region consist of contorted and thoroughly metamorphosed igneous and sedimentary rocks of pre-Cambrian age. Unconformably overlying them is the Cambrian Deadwood formation, contain-



General view of Zortman; Ruby Gulch emerges in the center of the scene.
Looking northwest.



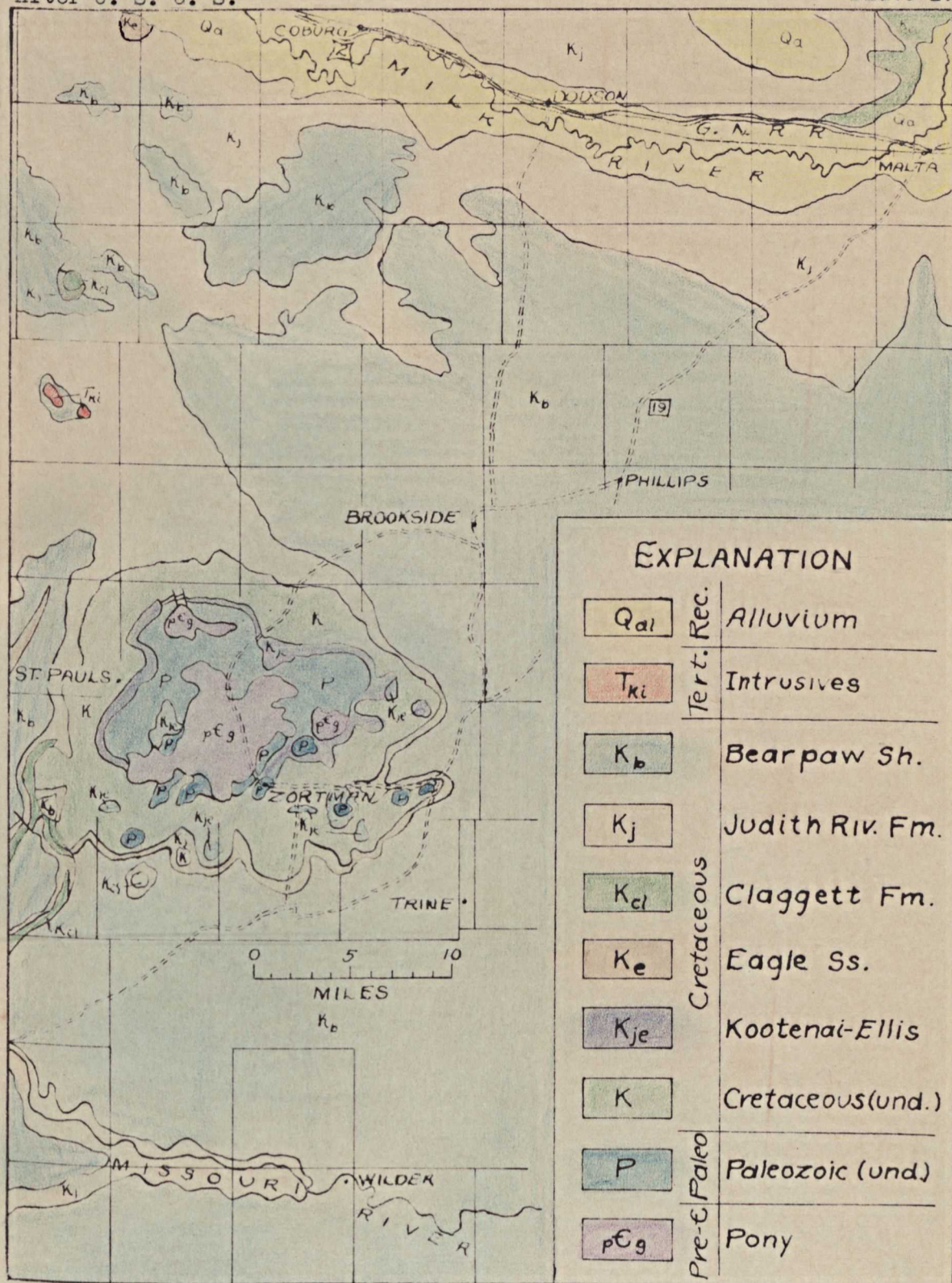
View showing the Ruby Gulch mill and tailings dump; Zortman is at the
mouth of the gulch. Looking southeast from 200 portal.

ing a basal beach conglomerate. This is succeeded by a dark, fetid limestone generally ascribed to the Ordovician Big Horn group, which in turn is followed by the dark Jefferson limestone. Next in the succession are the thin-bedded fossiliferous Lodgepole and the white massive Mission Canyon limestones, constituting the Madison group of formations in these mountains. Separated from them by an unconformity, indicating the lapse of a long period, is the Jurassic Ellis formation. The regular sequence continues upward with the freshwater Kootenai formation, of Lower Cretaceous age, and sediments of the Colorado and Montana group. No doubt beds of late Cretaceous age were deposited across the area, but they have been removed by subsequent erosion from these mountains. Capping long sloping benches on the plains below are gravels of Tertiary, Quaternary and Recent age, concluding the stratigraphic sequence in the region. Ice of continental glaciation, which spread over northern Montana did not cover the Little Rocky mountains.

Rocks Exposed

Igneous Rocks

A large, thick mass of igneous rocks forms the central axis of the mountains, and is the country rock for the much important ore deposits. This mass, composed



GEOLOGIC MAP OF THE
LITTLE ROCKIES AREA

of syenite porphyry and other closely related varieties of alkali-rich rocks, is nearly circular and is about six miles in diameter. Near the outer rim of the mountains and separated by limestone from the main central mass of porphyry, rise buttes which are also cored with porphyry. The intruding porphyry is limited so far as is known to the area of crystalline schists and Cambrian strata. Planes of weakness, which were especially favorable for intruding rock, appear to have existed in the horizons between the schist and the Cambrian quartzite, and also at the top of the quartzite and in the Cambrian shales.

Since the structure of the mountains is that of a dome with strata dipping away from the central axis, the porphyry, a thick sheet intruded between sedimentary beds, also dips away from the center of the uplift. Although the highest peaks are capped with porphyry, crystalline schist occurs locally near the top of the divide and exposed in many places in the hollows of the gulches radiating from the mountains. The porphyry surrounds small areas of both schist and limestone, some of which are only a few feet in diameter and appear to be isolated masses which were caught in the upward movement of the intrusion. Other masses of limestone are

probably remnants, not yet eroded, of the beds which lie on the porphyry sheet. The porphyry's precise thickness has not been measured, as no favorable section is known; but it appears to be thickest in the central portion of the mountains and to thin out near the margin. At some places it is at least 4,000 feet thick, and it may be thicker. The contact between the schist and porphyry shows irregularities or "warpings" other than the ordinary dip toward the margin of the mountains; and the distribution of the two rock types with respect to the topography is not such as would result if the contact were simply a tilted plane. Therefore, the porphyry mass is an intrusive rock, and it is believed to be younger than the rocks which enclose it. In some places it must have come up across the crystalline schists, and at such places its contact with the schist is probably steeply inclined or vertical. At the points where the porphyry rose, it is likely to be found to extend downward to great depth.

Metamorphic Rocks

The oldest rocks are crystalline schists which are exposed in the deep gulches in the interior of the mountains, and rarely on the higher ridges near the crest. These schists are of pre-Cambrian age and are overlain by Cambrian quartzite, but at many places they

are separated from the Cambrian by the intruding porphyry. The prevailing rock type among the schists is a dark, glistening hornblende schist or amphibolite. Locally this is a garnetiferous, and elsewhere is rich in quartz and feldspar. On the road from Zortman to the Alabama mine, the schists consist of alternating beds of different character, and at some places quartzites are included in them, showing that the series is, in part at least, of sedimentary origin. These rocks everywhere have been profoundly metamorphosed.

Sedimentary Rocks

The Cambrian beds rest unconformably upon the metamorphic rocks, or are separated from them by intruding porphyry. At the base of the Cambrian is a quartzite bed about 75 feet thick, probably to be correlated with the Flathead quartzite of other parts of Montana. Overlain by it are shales and limestone, making altogether a series about 500 feet in total thickness. Above the Cambrian, with no apparent unconformity, is a succession of impure limestones, in which no fossils have been found, but which are presumably of Silurian or Devonian age. Resting upon these limestones are large massive beds of white or light-gray limestone rich in Carboniferous fossils. These rocks are more resistant to erosion than the underlying limestones, and form a

chain of ridges and peaks around the mountains, the continuity of which is interrupted here and there by valleys that have been cut through the limestone by numerous small streams flowing outward from the center of the mountains. This broken rim of Carboniferous rocks is a conspicuous feature of the landscape, and it has been aptly compared to the limestone girdle which encircles the Black Hills of South Dakota and other mountainous areas. On the low ridges which slope gently away from the mountains toward the plains, the Jurassic limestones overlies the Carboniferous beds and these in turn are covered by the Cretaceous sandstones and shales. The Jurassic and Cretaceous formations are not known to occur within the mountain group proper, but together they cover great areas of the surrounding plains and badlands country.

Structure

The Little Rocky Mountains consist of sedimentary and metamorphic rocks which have been uplifted into a domal structure. Thick sheets of porphyry were intruded. The younger beds have been eroded from the top of the dome, and in its broader features, the structure is simple. The dip of the beds, greater than the average slope of the mountains, is outward from the central axis of the mountains toward the surrounding plains. As a

result, the exposed beds in the center of the group are older than, and generally of a higher elevation than the overlying younger rocks. Approaching the mountains from the plains, one passes over successively older beds; and well toward the interior of the mountain group crystalline schists are encountered which have been highly metamorphosed and are older than any of the overlying bedded sedimentary rocks.

Geologic History

The geologic history of the Ruby Gulch area, as shown by exposed rocks, begins in early Proterozoic (Huronian) time, or possibly even earlier in Archean time, with marine deposition of a thick series of principally quartz-rich sandstones and shales and interbedded siliceous iron-magnesium carbonate layers.

Deposition was followed by the initiation of a long structural history. Prior to Beltian time (late Proterozoic) these sediments were altered and crumpled into the most complex feldspar and amphibole schists and gneisses termed the basal complex. Evidence of the deposition of the Belt series so widespread in western Montana is not present in the Little Rockies. It is assumed, therefore, that erosion was taking place during late Proterozoic time.

Marine inundation during the middle Cambrian

period resulted in deposition upon the pre-Cambrian metamorphic complex. Sedimentation, both marine and non-marine, continued with many interruptions through Paleozoic and Mesozoic time. However, there was no deformation, as the strata are all practically parallel.

Laccolithic intrusion combined with uplift and peripheral faulting occurred probably slightly later than the Rocky Mountain uplift (late Cretaceous or early Tertiary), possibly in Paleocene time. This porphyry intrusion was followed by intense faulting and fracturing at right angles to the faults. As a late phase of igneous activity, ascending hydrothermal solutions, which caused alteration of the schist, filled these minute fractures and brought about deposition of the gold, pyrite, and associated minerals.

Erosion, accompanied by supergene alteration of the porphyry, the schist, and the ore deposits constitutes the last geologic event affecting the Ruby Gulch ore deposits. With erosion came the development of the placer deposits of the area.

Economic Geology

The gold deposits of the Little Rocky Mountains consist of the syngenetic types which include the unimportant placers, and the epigenetic deposits which include veins, disseminations, contact and replacement

deposits. The epigenetic deposits have been of chief economic importance. The district consists of two principal areas of production. The first area has some 51 claims including the August Mine in the western part of the mountains not far from Landusky. The second in the eastern part of the mountains near Zortman includes the Alabama and Ruby Gulch Mines. The areas on the eastern side is mined mainly for low-grade ore scattered abundantly through shear zones, and also for the contact and replacement deposits in limestone on Pole and Beaver gulches. Lodes in the eastern area all strike generally northwest, while the western area lodes strike generally northeast. The lodes contain small pockets from which high-grade ore has been mined. The high ridge between Regal and Antoine mountains appears to make the division between the two areas.

In addition to metalliferous deposits, the Little Rockies contain deposits of bentonite, sub-bituminous coal, and limestone and clay suitable for manufacturing of quicklime and cement. These are also areas favorable for quarrying building stone. These deposits have economic potentialities, but present high transportation costs make their exploitation inadvisable.

RUBY GULCH DISTRICT

General Geology

In the Ruby Gulch area the rocks consist of (1) a fine-grained, black amphibole schist, the most common rock, (2) finely-banded white gneiss, (3) mica and garnet schist, (4) interbedded hornblende schists and white quartzites with rounded grains, and (5) a rock referred to as a sheared granite gneiss, and also as a pink gneiss with feldspar crystals.

In the immediate area studied, however, there were only (1) a light-colored gneiss, (2) amphibolite, (3) pre-Cambrian granite gneiss, and (4) intrusive porphyry. The surface geologic map shows almost equal exposures of gneiss and porphyry, with amphibolite present in minor quantities, and the pre-Cambrian gneiss in such small amounts as to be insignificant. Underground geologic maps show a dominance of intrusive porphyry.

Rock Types

Porphyry

The dacite porphyry country rock in the area contains conspicuous phenocrysts of feldspar from one-eighth to three-eighths inch in diameter, the whole imbedded in a groundmass ranging in color from light gray in weathered ores to dark gray or nearly black in the



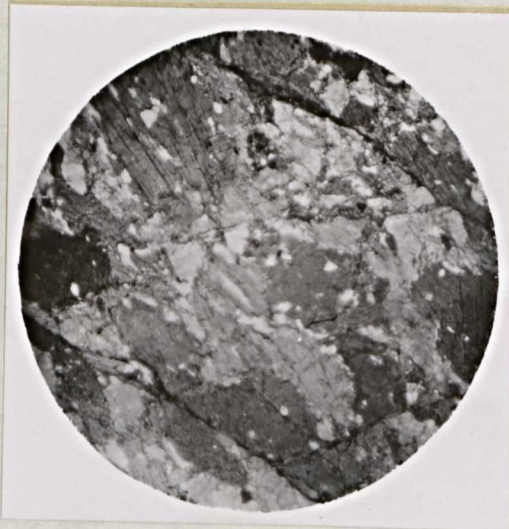
Plate V

Panoramic view of the Ruby Gulch Mine area, looking west.

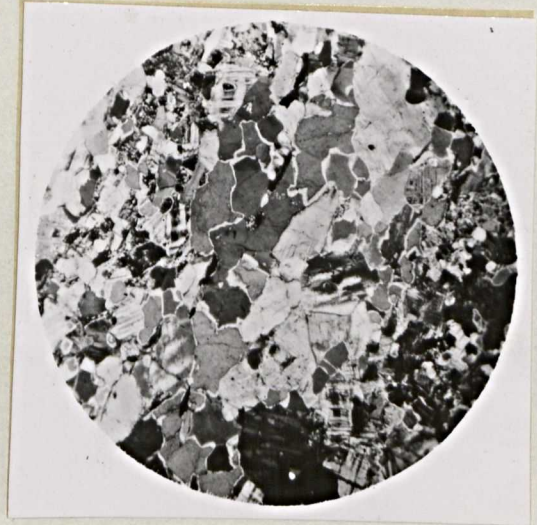
mineralized zone. The weathered rock assumes a reddish light brown color due to limonite stains, and the porphyritic texture becomes less apparent.

The phenocrysts are mostly irregular anhedral crystals whose crystalline outline is not very well shown, but which in most cases has been destroyed by weathering or by alteration from hydrothermal solutions.

Microscopically, the minerals of the dacite are plagioclase and quartz with the necessary mineral pyrite which probably has been introduced by later mineralization. The feldspar shows an extinction angle of about 11° indicating an Ab-An ratio in the oligoclase range. Evidence of twinning has been almost completely destroyed by intense hydrothermal alteration in the mineralized portions. Some of the crystals show repeated zoning, as many as five distinct zones may be present. There is a change in composition towards the margin where the phenocrysts become richer in albite. The phenocrysts are characterized by abundant glassy inclusions concentrated in the central portion and absent in the surrounding marginal area. The quartz is present as small, irregular anhedral crystals one-fourth to one-eighth the size of the phenocrysts of feldspar. A minor amount of pyrite is present in the groundmass, and has formed along the cleavage of the phenocrysts. The groundmass



A



B



C

PHOTOMICROGRAPHS OF THIN SECTIONS OF RUBY GULCH ORE. $\times 16$

- A. Amphibolite showing channelways of mineralizing solution. Ordinary light.
- B. Typical gneiss showing bands of schistosity. Crossed nicols.
- C. Dacite porphyry showing zoning of oligoclase phenocrysts. Crossed nicols.

or matrix is glassy, and contains numerous small crystals of quartz. The matrix constitutes 50% of the rock with the remainder being made up of the larger crystals.

Gneiss ("Schist")

The principal country rock is a fine-grained, light-colored gneiss whose foliation is due to parallelism of mineral grains. This rock is called "schist" locally by the miners and is designated as such on the maps. It contains abundant feldspar, some quartz, and a few accessory minerals. Mica is subordinate. The feldspars show a very light color except on weathered surfaces which have been stained by limonite to a yellowish-brown.

Microscopic study of the gneiss reveals that the feldspar is chiefly oligoclase which comprises 80% of the rock. The remainder is 15% quartz and 5% amphibole. The oligoclase crystals are irregular anhedral crystals having sharply-defined boundaries and containing inclusions along the cleavages and showing twinning. The quartz crystals are anhedral to subhedral. The amphibole is later than the feldspar, locally cutting across the crystal boundaries.

Amphibolite

The amphibolite is a dark-colored, fine-grained

metamorphic rock in which foliation is due to the parallel arrangement of the amphibole blades. Light-colored feldspar is present between the layers of amphibole. The weathered surface of the rock is reddish due to iron stain.

Under the microscope, the mineral constituents are identified as orthoclase (15%), hornblende (80%), and quartz, limonite, and magnetite (5%). The hornblende crystals are large and anhedral, and often contain orthoclase inclusions. They are traversed by fractures along whose margins alteration has taken place. Scattered grains of still later magnetite are present. Limonitic stains are present in amounts dependent on the degree of alteration.

Structure

A group of north to northwest trending nearly vertical faults is present in the area. The walls are prominently slickensided and grooved. The faults from zones which are cut by numerous steeply-dipping fractures at right angle to the faults. Crushing has been intense locally, and thin streaks of gouge have resulted. The faults and fissures have served as channelways for solutions. The gold, with associated pyrite is related to the porphyry intrusive, and the lodes are found in the

fissure zones which afford a structural control on the lodes. The lodes are vein-like, and follow along the fissures, although more accurately they are intense disseminations in crushed zones. Gold and pyrite are also found disseminated in the porphyry, and they occur more abundantly along the contact between the schist and porphyry.

Minerals

Gold

Finely-disseminated gold occurs in association with quartz and pyrite, and in the area studied gold is not visible to the naked eye or with a hand lens. Most of the gold is so finely disseminated that it cannot be successfully amalgamated.

Silver

Most of the ore carries minor amounts of silver, which are recovered by the cyanide process. The bullion contains approximately three to seven times as much silver, as gold, by weight.

Quartz

Quartz occurs as a groundmass constituent of the porphyry, and also as small veinlets in the porphyry. It also takes the form of silicification of the porphyry wall rock where it is extremely fine-grained quartz.

Feldspar

The plagioclase feldspar, oligoclase, is an abundant constituent of the ore, occurring mainly as phenocrysts in the porphyry. Orthoclase occurs as a secondary mineral in the amphibolite.

Magnetite

Magnetite is present as scattered grains which are a primary constituent of the amphibolite.

Kaolin

Kaolin is formed through the alteration of the feldspar.

Pyrite

Pyrite is the only sulfide in the ore and is present in quantity at depth. It occurs as crystals and small, irregular bodies replacing the porphyry. It fills small cracks which cut the porphyry, and it often coats the fragments of the crushed ore. Iron sulfide having the habit of marcasite, but with a yellow color, was noted in the Independence pit.

Limonite

Limonite is present in the oxidized ore, as earthy limonite, as pseudomorphs after pyrite, and as a coating on fragments of crushed ore.

Description of Pits

General

In the area studied the mining of the ore is carried on by the glory hole method utilizing three open pits, the Independence, the OK, and the Ruby, from which the ore is drawn downward through chutes to the 500 level, which is the common haulage level. These chutes are unsatisfactory since they have no adjacent manway to service them. The pits are located along a ridge trending in a northwesterly direction, roughly following the fissure system described earlier in this report. The pits encompass contacts between pre-Cambrian schist and intruded porphyry.

The Alabama pit, one mile west of the OK pit, and west of the mapped area is larger than any of the other pits. A wagon drill and a bulldozer are employed to bench this pit, and the ore is drawn through chutes to the haulage level. This haulage level, which is at the same elevation as the 500-foot level of the Ruby mine, has its portal on a covered surface track which originates at the portal of the Ruby adit.

Independence Pit

The Independence pit is 385 feet northwest of the 500 portal. It is approximately 260 feet in length,

Plate VII



A. View of the Independence and OK pits. Blacksmith shop and dry at lower left. 200 level waste dump in the center. Looking north.



B. The Independence pit. Note the slickensided fault. Looking north.

100 feet in width, and roughly 150 feet in depth. The pit is located largely in pre-Cambrian schist adjacent to the contact of intrusive porphyry. A series of horse-tailing faults extend along the long direction of the pit. Faulting was accompanied by fracturing which resulted in channelways for passage of hydrothermal solutions making possible deposition of the gold and associated pyrite. Since the gold is so finely disseminated in both the schist and porphyry no distinction can be made for selective mining by customary methods. Consequently the extent of mining into the surrounding rock is determined by assay. The ore is drawn through chutes to the 500 level.

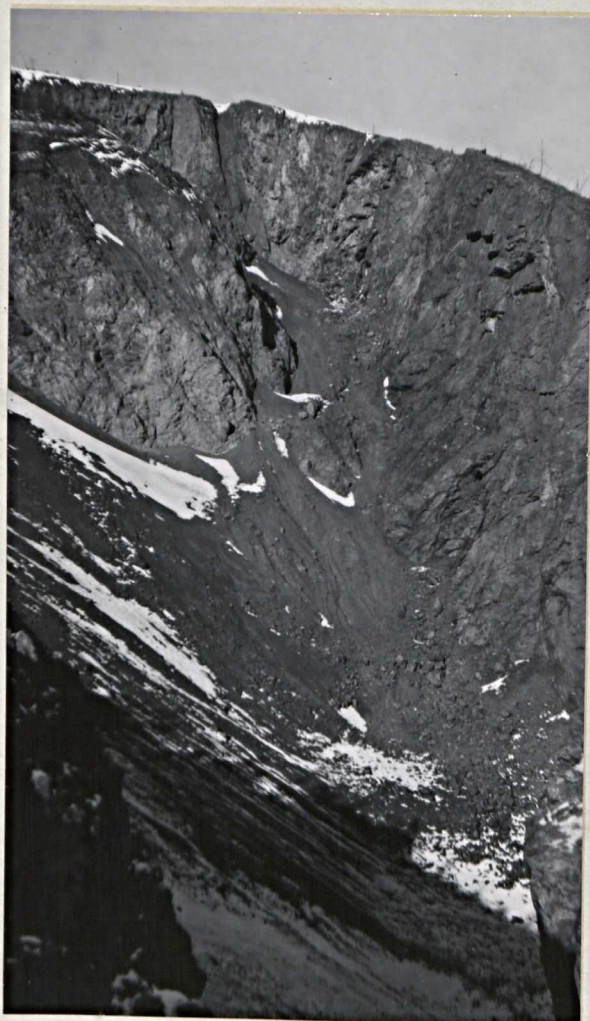
OK Pit

The OK pit lies 325 feet directly north of the Independence pit, and it is approximately the same size. In addition to many small lateral faults one major fault extends along the greater direction of the pit. The rock on the east side of the fault is schist, and that on the west side is porphyry. A series of cross fractures also accompanied the faulting in this pit. The gold is finely disseminated as in the Independence pit, with major local concentrations in the porphyry immediately adjacent to the major fault.

Plate VIII



A. General view of the
Ruby pit. Looking west.



B. The Ruby pit. Note the
north trending faults.
Looking north.

Prior to the adoption of the glory hole method of mining the ore was selectively removed by stoping the high grade concentrations. These workings are visible in this pit at the present time.

Ruby Pit

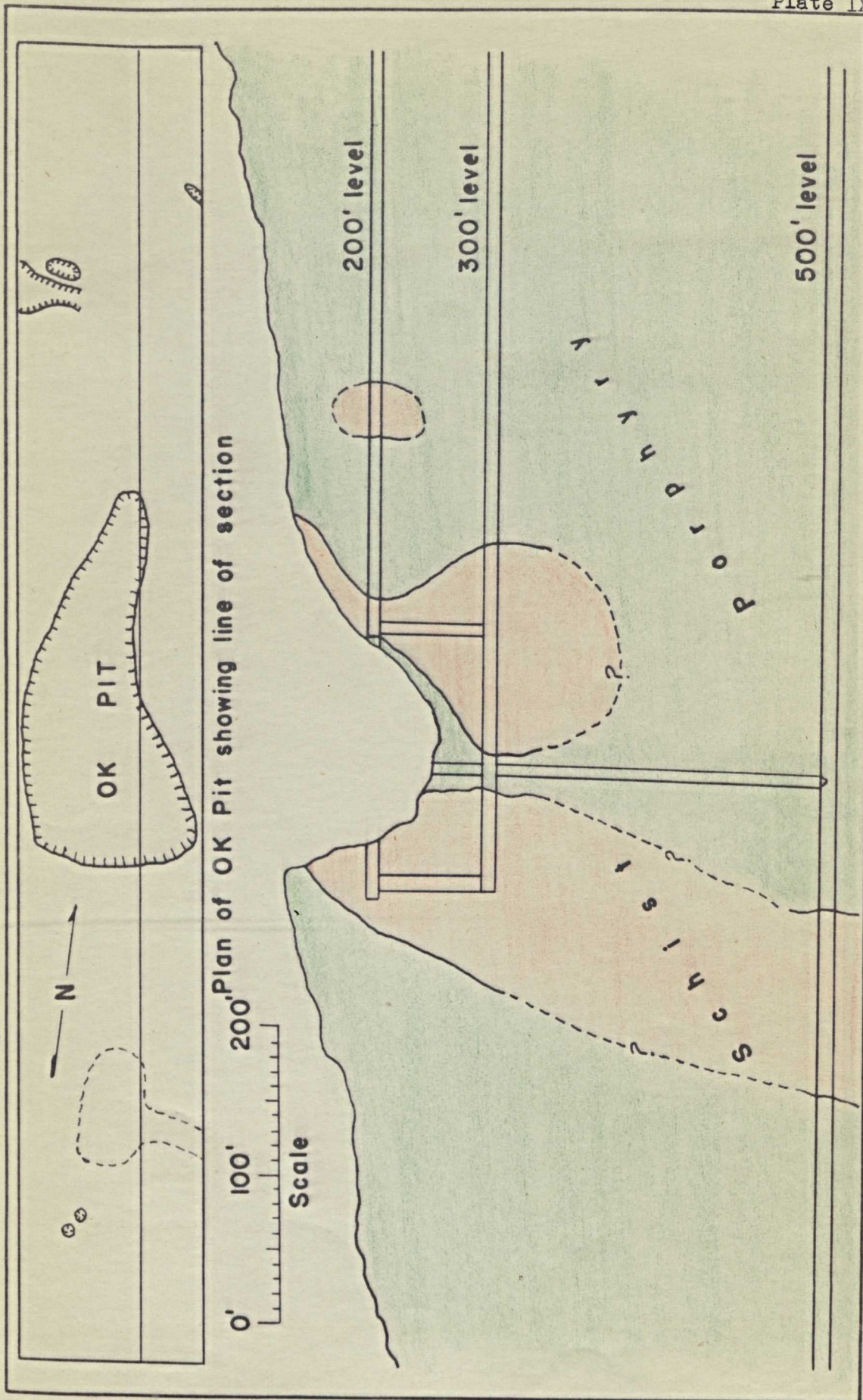
The largest pit in the area studied is the Ruby pit which is 625 feet north of the OK pit. It is approximately 850 feet in length, 325 feet in maximum width, and has an estimated depth of 225 feet. Mineralization and gold deposition is similar to that in the other two pits. Local concentrations of high grade ore were removed by selective mining during early periods of mining.

A major fault separates the schist on the west from the porphyry on the east. In the northern part of the pit west of this fault amphibolite crops out on the surface. Finely disseminated gold occurs along minute fractures in this rock, as well as is the schist and porphyry as disseminations.

This pit is structurally similar to the others having a system of abundant faults and numerous cross fractures.

Ore Treatment

All ore is leached of its gold and silver



POSTULATED CROSS-SECTION OF OK PIT
RUBY GULCH MINE, ZORTMAN, MONTANA

content at the mine, and no other metals are recovered. The general process is that commonly followed in cyanide plants. Perhaps the most interesting feature of the treatment is the lack of fine grinding, the average size of the leach material being one-half inch. This is possible because the gold and silver occur finely disseminated along minute fractures in the schist and porphyry. Thus, fine crushing is not needed to expose the metals to the leaching action of the cyanide.

The mine's main haulage level (the 500 level) is at the same elevation as the coarse ore bin at the mill, so that ore can be trammed directly to the mill after loading in the mine. Trolley locomotives and two ton side dump cars operate on the 24-inch gauge main haulage track, which passes through a shed-covered haulageway for an estimated distance of one half mile. The mill has a capacity of 300 tons of ore per 24-hour day. Ore drawn from the coarse ore bin is transported to the primary gyratory crusher after passing over an inclined grizzly with $1\frac{1}{4}$ -inch opening which serves to remove mud and fines from the crusher feed. Ore passing through the primary crusher averages -2-inches. Both the coarse crushed ore and the grizzly undersize travel by gravity to the foot of a bucket-type belt elevator which lifts the ore to a 50 ton storage bin. Ore is then fed from this bin by conveyor

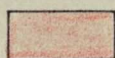
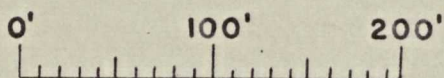
belt to a set of rolls which crush to $-1\frac{1}{4}$ -inch. A second set of rolls in series with the first, and also fed by conveyor belt, reduces the $-1\frac{1}{4}$ -inch feed to $-\frac{1}{2}$ -inch. This is the final grinding product, and it falls directly onto a 250-foot conveyor belt which transports the ore to any of seven 300-ton capacity sand leach cyanide tanks. An automatic head sampler cuts one-half of one per cent of the feed. Samples for each tank are coned and quartered to about 50 pounds, a size which can be handled in the assay office.

The metallurgy of the ore is simple and follows a seven day cycle. One tank is filled, and one sluiced out every day. After a tank is filled with ore it is covered with mildly alkaline sodium cyanide solution. Each tank holds about 100 tons of solution in addition to the 300 tons of ore. Pregnant solution is drawn from the tank each day, and an equal quantity of barren solution is added. After three days all of the solution is taken from the tank to aerate the ore, after which the solution is returned. This process takes about two hours. The normal leaching process is then continued for about two and one-half days after which the pregnant solution is taken from the tank. The tank is then sluiced out and is ready to repeat the cycle.

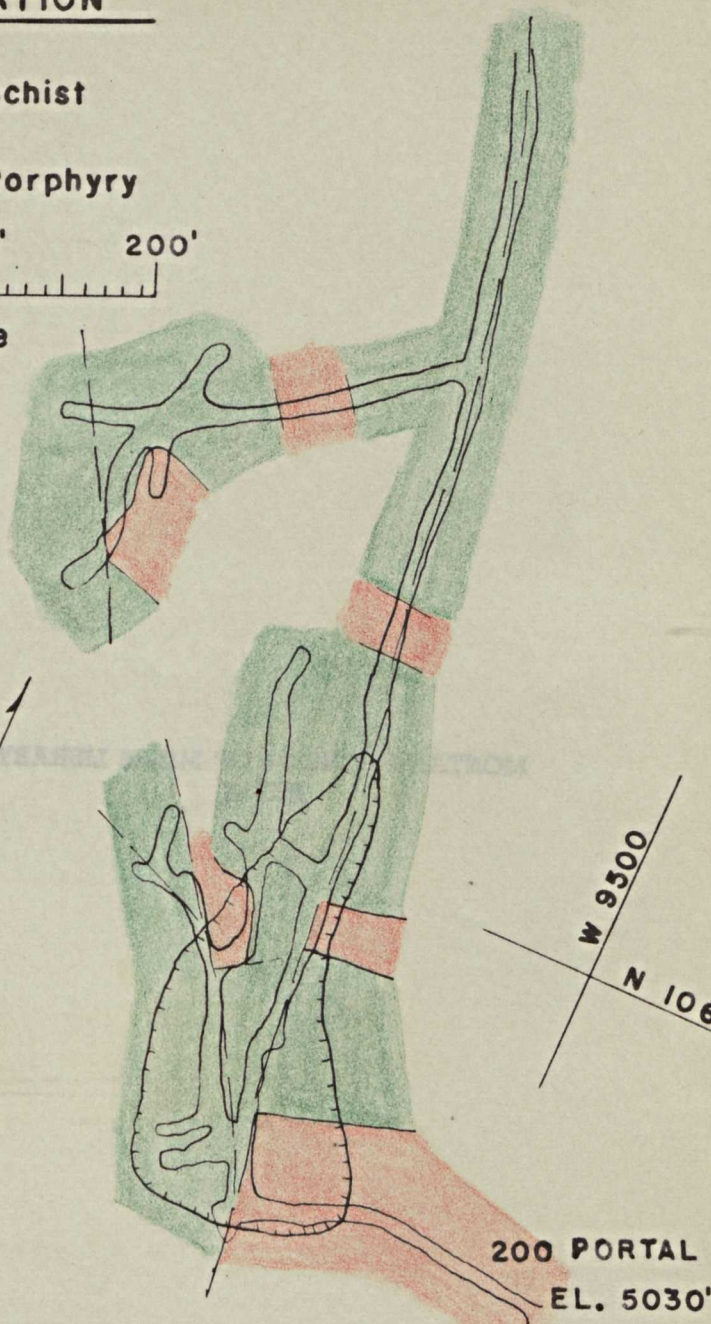
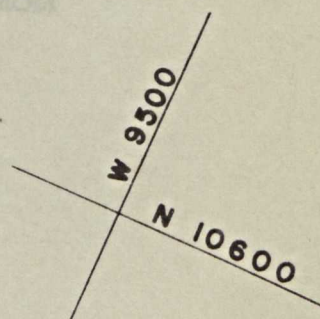
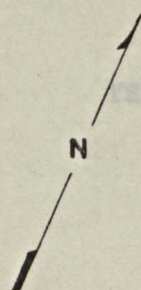
The pregnant cyanide solution is pumped first

to a storage tank from which it goes to a vacuum tank to remove most of the oxygen, a hindrance to complete precipitation of gold and silver. A vacuum is maintained on the tank by means of a pump. The solution is picked up at the outlet of the vacuum tank by a centrifugal pump, zinc dust is then added, and the mixture is pumped to a bag tank where approximately 40 bags filter the precipitated gold and silver and excess zinc dust from the solution. The solution is fed into the bags at about 5 pounds per square inch pressure.

The precipitation bags are removed at regular intervals and replaced by new ones. The precipitates are dried and small amounts of flux added. The mixture is put in a large graphite crucible in a hot type melting furnace. The melt consisting of gold, silver and slag is poured directly into a mold from which the bar of bullion is removed while still at a dull red heat. The bullion is sampled by assaying drill cuttings from opposite corners. It is stamped with a number, placed in a canvass bag and shipped by express to the United States Mint at Denver, Colorado. The bullion normally contains from three to seven times as much silver as gold by weight.

EXPLANATION**Schist****Porphyry**

Scale

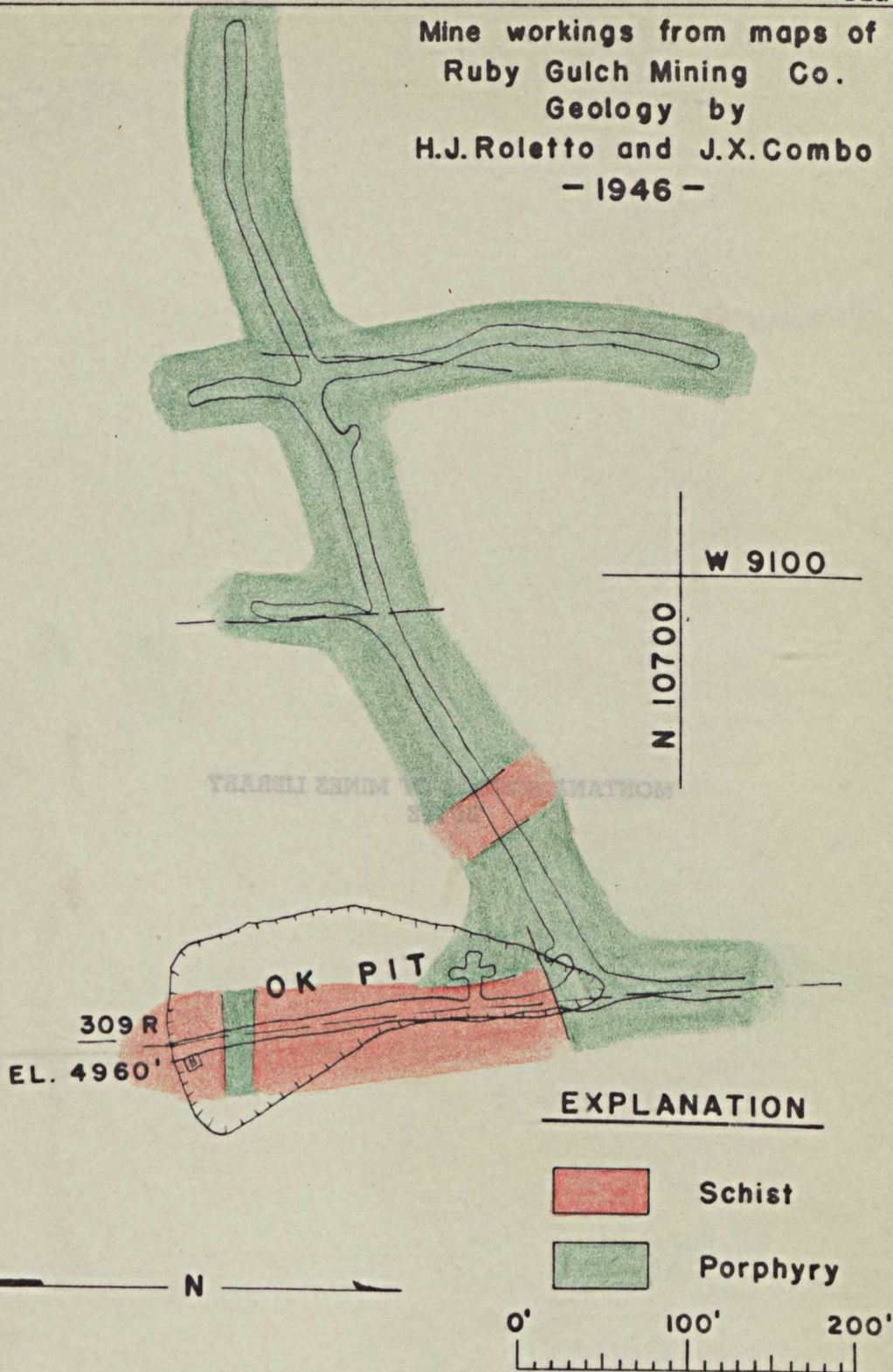


Mine workings from maps of Ruby Gulch Mining Co.
Geology by H.J. Roletto and J.X. Combo - - - - 1946

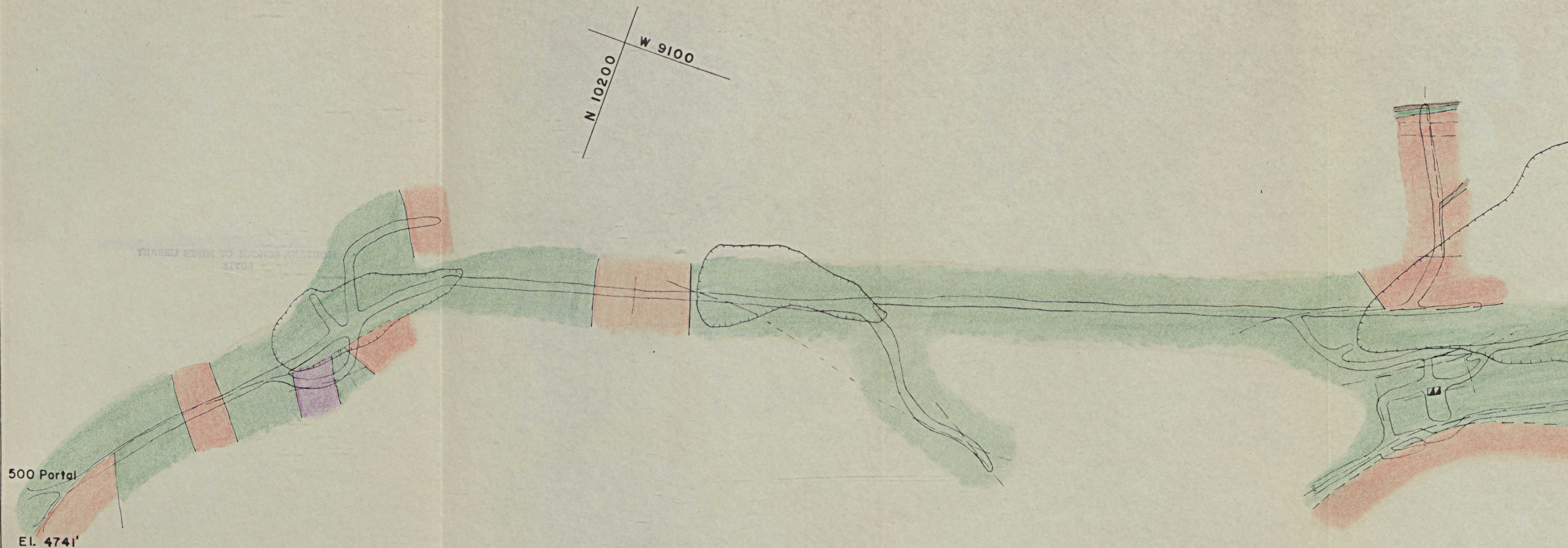
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BUTTE

**GEOLOGIC MAP 200 LEVEL
RUBY GULCH MINE
ZORTMAN , MONTANA**

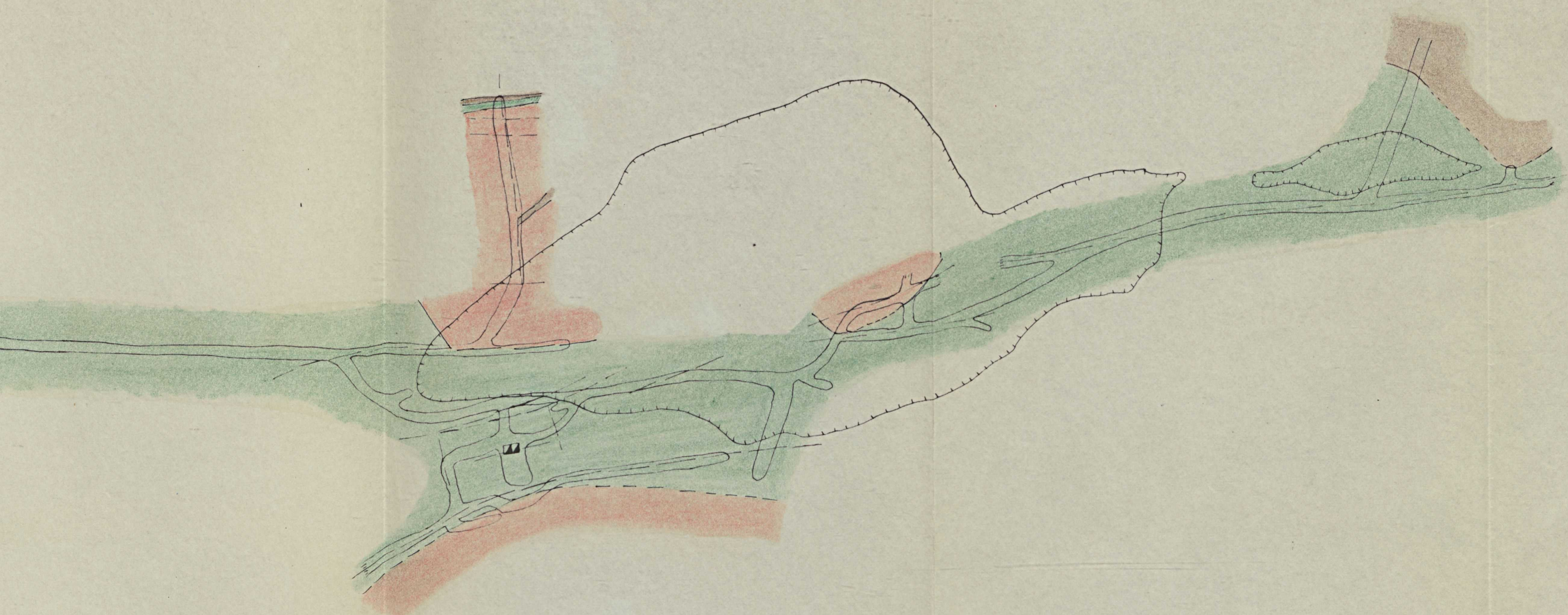
Mine workings from maps of
 Ruby Gulch Mining Co.
 Geology by
 H.J. Roletto and J.X. Combo
 - 1946 -







**GEOLOGIC MAP 300 LEVEL
 RUBY GULCH MINE
 ZORTMAN, MONTANA**

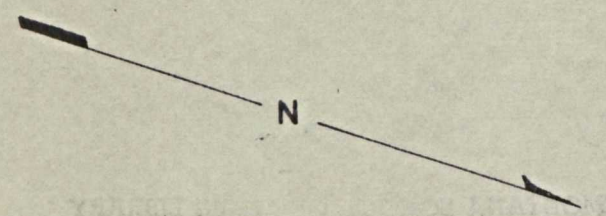


Mine workings and surface features from maps of Ruby Gulch Mining Co.
Geology by H.J. Roletto and J.X. Combo ----1946



EXPLANATION

- | | |
|---|-------------|
|  | Gneiss |
|  | Schist |
|  | Porphyry |
|  | Amphibolite |



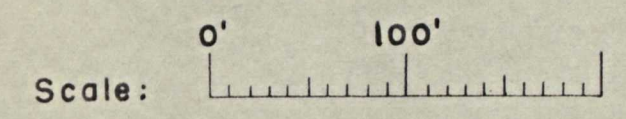
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GEOLOGIC MAP

— 500 LEVEL —

RUBY GULCH MINE

ZORTMAN, MONTANA.



500 Portal
El. - 4741'

INDEPENDENCE

PIT

OK

PIT

N 10700

W 9600

R U B

Mine workings and surface features from maps of Ruby Gulch Mining Co.
Geology by H.J. Roletto and J.X. Combo ---- 1946



EXPLANATION

- Gneiss
- Schist
- Porphyry
- Amphibolite

N

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GEOLOGIC MAP
RUBY GULCH MINE
ZORTMAN, MONTANA.

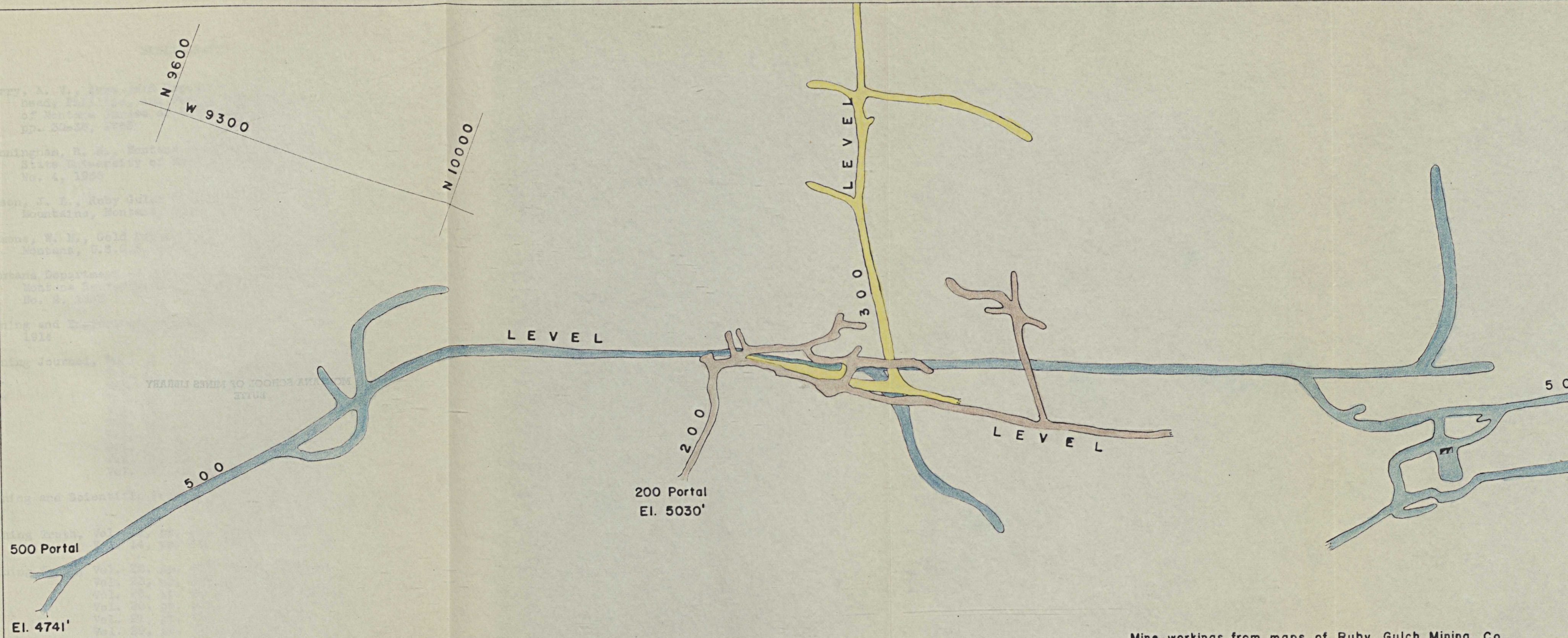
Scale = 0' 100'

U.S.B.M. G 275

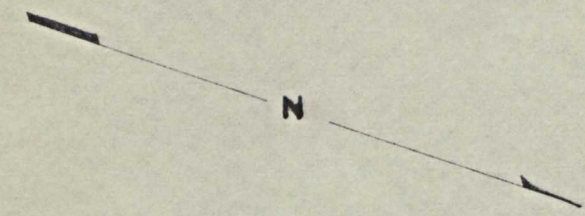
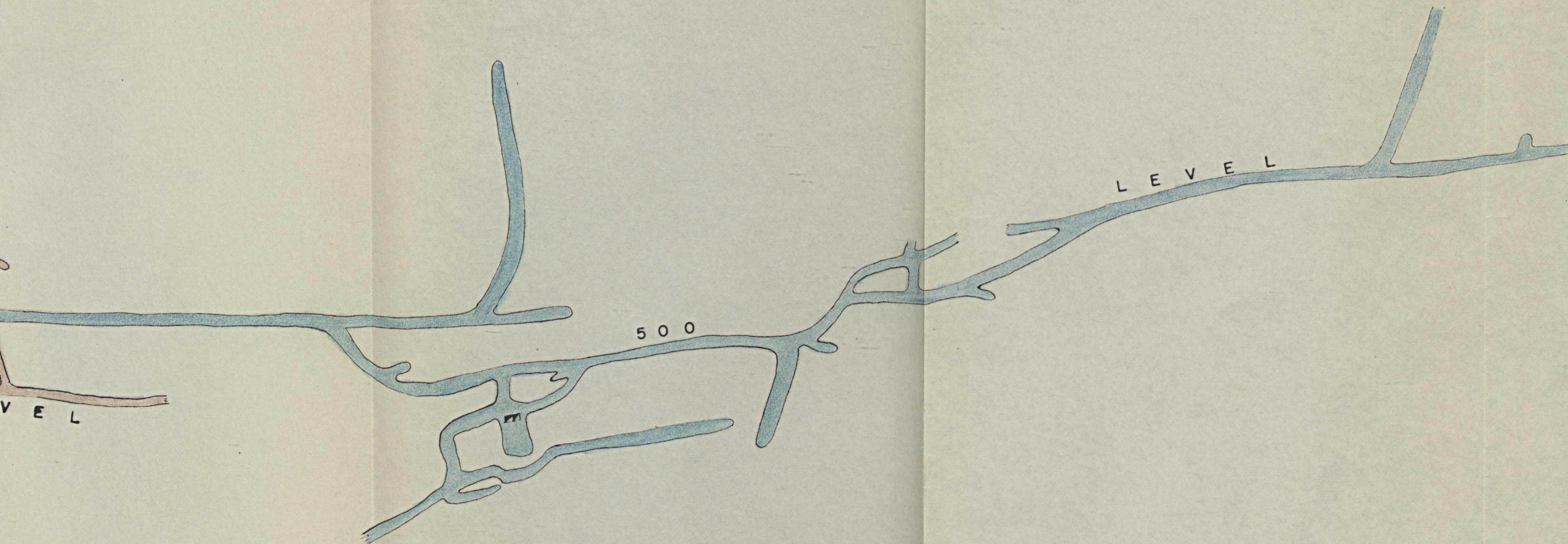
250'

Maps of Ruby Gulch Mining Co.
X.Combo ---- 1946

N 9600
W 9300
N 10000

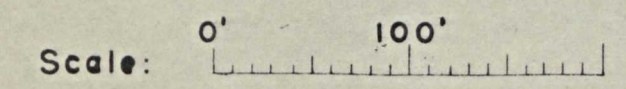


Mine workings from maps of Ruby Gulch Mining Co.



MINE MAP
RUBY GULCH MINE
ZORTMAN, MONTANA.

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Mine workings from maps of Ruby Gulch Mining Co.

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